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HELICALLY CRIMPED, SHAPED, SINGLE POLYMER FIBERS AND ARTICLES MADE THEREFROM

BACKGROUND OF THE INVENTION

This invention concerns polymer fibers and articles that may be made using such fibers. More particularly, these fibers may be used in absorbent articles that are useful in personal care products like disposable sanitary napkins, diapers, training pants, incontinence garments, wound care products and the like. These articles typically have a structure including a body side liner, a liquid impervious outer layer or "baffle", and an absorbent core between the liner and the baffle.

Crimped fibers have been found to be useful in materials for personal care products because of their ability to give increased thickness to the materials, as well as other properties.

Bicomponent fibers have previously been used to produce crimped fibers. The fibers may have one side made from one polymer and another side made from a different polymer and are also used as binder fibers. Other options include having one polymer comprise the center area of the fiber and another the outer area though symmetrical fibers are less attractive for crimping. Still another option is to produce a fiber having legs or lobes with different polymers making up different parts of the legs or lobes (US Patent 5,707,735). These fibers perform adequately but are relatively expensive to produce, since they are made from more than one polymer. The equipment to produce these fibers is also relatively more

expensive and complicated, as compared to single polymer fibers, since multiple channels must be machined into the fiber spinneret plate.

Mechanical crimping of single component fibers is another option known in the art, though this is a slow and cumbersome manufacturing process. The type of crimp induced by mechanical crimping, generally by passing fibers between intermeshing rollers, is usually a zig-zag crimp in only one plane.

Despite past development of absorbent structures, there remains a need for improved absorbent structures that can adequately reduce leakage from absorbent products, such as feminine hygiene products and infant care products, and be simpler to manufacture and still more cost effective. There is a need for an absorbent structure that can provide improved handling of liquid surges by more effectively intaking, distributing and retaining repeated loadings of liquid. There remains a need for materials to be made economically and quickly for use in such absorbent structures, where the materials are made using helically crimped fibers. Such materials should have liquid handling properties superior to those made from previously used fibers.

SUMMARY OF THE INVENTION

In response to the discussed difficulties and problems encountered in the prior art, a new structural material comprising a nonwoven web having good bulk and resilience properties to allow for more efficient liquid handling is provided. This is achieved by a material for use in personal care absorbent articles wherein the material is made with single component fibers having a helical crimp. A variety of polymers may be used to produce the nonwoven of this invention including polyolefins, polyamides, polyesters, rayon, acrylics, superabsorbents, and regenerated cellulose, though polyolefin is preferred and most

preferably polypropylene. The nonwoven fabric maybe bonded by thermal point bonding, point unbonding, through air bonding with the use of a binder, ultrasonic bonding and hydroentangling. The nonwoven fabric of this invention may be used in a variety of personal care products, including diapers, training pants, absorbent underpants, adult incontinence products, bandages and other wound care products and feminine hygiene products. The nonwoven fabric of this invention maybe used as a surge material, a hoop component of a hook and loop fabric, and as an absorbent core, an outercover, a liner, a filtration media, and wipers, among other things.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram of an apparatus for manufacturing spunbond fibers.

Figure 2 is a cut-away side view of dual capillaries for fiber production.

Figure 3 is a cross-sectional view of dual capillaries for fiber productions showing the differential shape of the capillaries.

Figure 4 is a cut-away side view of a capillary for producing a homofilament spunbond fiber.

DEFINITIONS

As used herein, the following terms have the definitions ascribed to them.

The term "disposable" includes being disposed of after use and not intended to be washed and reused.

As used herein, the term "nonwoven fabric or web" means a web having a structure of individual fibers or threads which are interlaid, but not in an identifiable manner, as in a

knitted fabric. Nonwoven fabrics or webs have been formed from many processes such as, for example, meltblowing processes, spunbonding processes, and bonded carded web processes. The basis weight of nonwoven fabrics is usually expressed in ounces of material per square yard (osy) or grams per square meter (gsm) and the fiber diameters useful are usually expressed in microns. (Note that to convert from osy to gsm, multiply osy by 33.91). As used herein, the term "spunbonded fibers" refers to small diameter fibers which are formed by extruding molten thermoplastic material as filaments from a plurality of fine, usually circular capillaries of a spinneret with the diameter of the extruded filaments then being rapidly reduced as by, for example, in U.S. Patent 4,340,563 to Appel et al., U.S. Patent 3,692,618 to Dorschner et al., U.S. Patent 3,802,817 to Matsuki et al., U.S. Patent 3,338,992 and U.S. Patent 3,341,394 to Kinney, U.S. Patent 3,502,763 to Hartmann, and U.S. Patent 3,542,615 to Dobo et al. Spunbond fibers are generally not tacky when they are deposited onto a collecting surface. Spunbond fibers are generally continuous and have average diameters (from a sample of at least 10) larger than 7 microns, more particularly, between about 10 and 30 microns. The fibers may also have shapes such as those described in U.S. Patent 5,277,976 to Hogle et al., U.S. Patent 5,466,410 to Hills, and U.S. Patent 5,069,970 and U.S. Patent 5,057,368 to Largman et al., which describe hybrids with unconventional shapes.

As used herein the term "conjugate fibers" refers to fibers which have been formed from at least two polymers extruded from separate extruders but spun together to form one fiber. Conjugate fibers are also sometimes referred to as multicomponent or bicomponent fibers. The polymers are usually different from each other though conjugate fibers may be monocomponent fibers. The polymers are arranged in substantially constantly positioned distinct zones across the cross-section of the conjugate fibers and extend continuously along the length of the conjugate fibers. The configuration of such a conjugate fiber may be, for example, a

sheath/core arrangement wherein one polymer is surrounded by another or may be a side by side arrangement, a pie arrangement or an "islands-in-the-sea" arrangement. Conjugate fibers are taught in US Patent 5,382,400 to Pike et al. and may be used to produce crimp in the fibers by using the differential rates of expansion and contraction of the two (or more) polymers.

As used herein the term "biconstituent fibers" refers to fibers that have been formed from at least two polymers extruded from the same extruder as a blend. The term "blend" is defined below. Biconstituent fibers do not have the various polymer components arranged in relatively constantly positioned distinct zones across the cross-sectional area of the fiber and the various polymers are usually not continuous along the entire length of the fiber, instead usually forming fibrils or protofibrils which start and end at random. Biconstituent fibers are sometimes also referred to as multiconstituent fibers.

As used herein the term "blend" means a mixture of two or more polymers while the term "alloy" means a sub-class of blends wherein the components are immiscible but have been compatibilized. "Miscibility" and "immiscibility" are defined as blends having negative and positive values, respectively, for the free energy of mixing. Further, "compatibilization" is defined as the process of modifying the interfacial properties of an immiscible polymer blend in order to make an alloy.

"Single polymer fibers" means fibers made from one polymer from one extruder. A nonwoven web of single polymer fibers may have only the single polymer fibers or may be a blend of single polymer fibers and other fibers. Such a web may also have a layer of single polymer fibers and layers of other types of fibers as well. A single polymer fiber may also be made from differing polymers along its length and as a biconstituent fiber blend but not as a conjugate fiber. This means that at any point in the fiber (except for a small area of transition) the fiber is made from only one polymer, though this may not be the same polymer as in another section along the fibers' length.

As used herein, the term "bonded carded web" refers to webs made from staple fibers which are sent through a combing or carding unit, which breaks apart and aligns the staple fibers in the machine direction to form a generally machine direction-oriented fibrous nonwoven web. Such fibers are from a few millimeters to centimeters in length and are usually purchased in bales which are placed in a picker which separates the fibers prior to the carding unit. Once the web is formed, it is then bonded by one or more of several known bonding methods. One such bonding method is powder bonding, wherein a powdered adhesive binder is distributed through the web and then activated, usually by heating the web and adhesive with hot air. Another suitable bonding method is pattern bonding, wherein heated calender rolls or ultrasonic bonding equipment are used to bond the fibers together, usually in a localized bond pattern, though the web can be bonded across its entire surface, if so desired. Another suitable and well-known bonding method, particularly when using bicomponent staple fibers, is through-air bonding, where one of the components acts as a binder.

As used herein, the term "hot air knife" or HAK means a process of pre- or primarily bonding a just produced microfiber, particularly spunbond, web in order to give it sufficient integrity for further processing, but does not mean the relatively strong bonding of secondary bonding processes like TAB, thermal bonding and ultrasonic bonding. A hot air knife is a device which focuses a stream of heated air at a very high flow rate at the nonwoven web immediately after its formation. This rate is generally from about 1000 to about 10000 feet per minute (fpm) (305 to 3050 meters per minute), or more particularly from about 3000 to 5000 feet per minute (915 to 1525 m/min). The air temperature is usually in the range of the melting point of at least one of the polymers used in the web, generally between about 200 and 550°F (93 and 290°C) for the thermoplastic polymers commonly used in spunbonding. The control of air temperature, velocity, pressure, volume and other factors helps avoid damage to the web while increasing its

integrity. The HAK's focused stream of air is arranged and directed by at least one slot (or closely spaced holes) serving as the exit for the heated air towards the web, with the slot running in a substantially cross-machine direction over substantially the entire width of the web. Since the foraminous wire onto which microfiber web polymer is formed generally moves at a high rate of speed, the time of exposure of any particular part of the web to the air discharged from the hot air knife is less a tenth of a second and generally about a hundredth of a second. The HAK is further described in US Patent 5,707,468, commonly assigned.

As used herein "thermal point bonding" involves passing a fabric or web of fibers to be bonded between a heated calender roll and an anvil roll. The calender roll is usually, though not always, patterned in some way so that the entire fabric is not bonded across its entire surface, and the anvil roll is usually flat. As a result, various patterns for calender rolls have been developed for functional as well as aesthetic reasons. One example of a pattern has points and is the Hansen Pennings or "H&P" pattern with about a 30% bond area with about 200 bonds/square inch as taught in U.S. Patent 3,855,046 to Hansen and Pennings. The H&P pattern has square point or pin bonding areas wherein each pin has a side dimension of 0.038 inches (0.965 mm), a spacing of 0.070 inches (1.778 mm) between pins, and a depth of bonding of 0.023 inches (0.584 mm). The resulting pattern has a bonded area of about 29.5%. Another typical point bonding pattern is the expanded Hansen Pennings or "EHP" bond pattern which produces a 15% bond area with a square pin having a side dimension of 0.037 inches (0.94 mm), a pin spacing of 0.097 inches (2.464 mm) and a depth of 0.039 inches (0.991 mm). Another typical point bonding pattern designated "714" has square pin bonding areas wherein each pin has a side dimension of 0.023 inches, a spacing of 0.062 inches (1.575 mm) between pins, and a depth of bonding of 0.033 inches (0.838 mm). The resulting pattern has a bonded area of about 15%. Yet another common pattern is the C-Star pattern which has a bond area of about 16.9%. The C-Star pattern has a cross-directional bar or "corduroy" design interrupted

by shooting stars. Other common patterns include a diamond pattern with repeating and slightly offset diamonds with about a 16% bond area and a wire weave pattern looking as the name suggests, e.g. like a window screen, with about a 19% bond area. Typically, the percent bonding area varies from around 10% to around 30% of the area of the fabric laminate web. As in well known in the art, the spot bonding holds the laminate layers together as well as imparts integrity to each individual layer by bonding filaments and/or fibers within each layer.

As used herein "pattern unbonded" or interchangeably "point unbonded" or "PUB", means a fabric pattern having continuous bonded areas defining a plurality of discrete unbonded areas as illustrated in US Patent 5,858,515 to Stokes et al. The fibers or filaments within the discrete unbonded areas are dimensionally stabilized by the continuous bonded areas that encircle or surround each unbonded area, such that no support or backing layer of film or adhesive is required. The unbonded areas are specifically designed to afford spaces between fibers or filaments within the unbonded areas.

"Hydrophilic" describes fibers or the surfaces of fibers which are wetted by the aqueous liquids in contact with the fibers. The degree of wetting of the materials can, in turn, be described in terms of the contact angles and the surface tensions of the liquids and materials involved. Equipment and techniques suitable for measuring the wettability of particular fiber materials can be provided by a Cahn SFA-222 Surface Force Analyzer System, or a substantially equivalent system. When measured with this system, fibers having contact angles less than 90° are designated "wettable" or "hydrophilic", while fibers having contact angles equal to or greater than to 90° are designated "nonwettable" or hydrophobic.

As used herein, the term "personal care product" or "personal care absorbent product" means diapers, training pants, absorbent underpants, adult incontinence products, bandages and other wound care products and feminine hygiene products.

TEST METHODS

Compression test: The compression test measures the resistance to compression and resiliency of a material. This relatively simple test uses a Compressometer from the Frazier Precision Instrument Co., Inc., 210 Oakmont Avenue, Gaithersburg, MD 20760 and is performed generally according to the US Department of Commerce, Bureau of Standards Research Paper RP561 published in the Bureau of Standards Journal of Research, Vol. 10, June 1933, p. 705-713. The Compressometer has a foot of 2.54 cm (one inch) in diameter under which the sample is placed. Force is applied to the sample vertically and is monitored by a dial indicator. The thickness is measured at 0.1 psi load and at a number of pressures as the load is increased to 3 psi. After reaching 3 psi, the thickness is measured as the load is gradually reduced, in order to provide a resiliency measurement.

Opacity: This test measures the light transmittance through a sample material. The test equipment is a HunterLab Color Difference Meter model D25, available from HunterLab of Naperville IL, 60540. The test specimen must be large enough to cover the 0.5 inch (1.27 cm) test aperture or port and the sample tested at one position, in this case testing the anvil side of the sample, turned 90 degrees and re-tested and the results averaged.

Peel Test: The peel force value measures the force needed to peel apart a hook and loop fastening system at approximately a 180 degree angle and can be determined in accordance with standard procedure ASTM D5170, approved Sept. 15, 1991 and published Nov. 1991; with the following particulars. The loop material to be tested is cut into a rectangle, 76 mm (3 inch) by 152 mm (6 inch) with the longer dimension in the cross-machine direction. The loop material is placed under the clamping plate of a rolldown machine. The hook material is placed on top of the loop material and attached by the rolldown machine using a 2 kg roller.

A suitable rolldown machine is part number HR-100 available from Chemsultants International, of Mentor, Ohio. During the engagement of the fastener components, the roller is rolled over the test specimen through one cycle in the direction of the cross-wise "width" of the sample. In addition, the initial peel by hand to "raise the loops" is omitted. After the hook and loop are properly attached, the combination is placed in the testing apparatus, an Instron Model 2712-004 tensile tester with 102 mm (4 inch) rubberized grip faces (Instron Corporation, Canton MA 02021). The hook base is inserted in the upper grip and the loop in the lower in such a manner that the movement of the grips away from each other will result in the peeling apart of the two materials. Slack is removed and the machine is started. The tester is set with a crosshead speed of 500 mm/min. and a gage length of 76 mm. Measurements are begun at 10 mm and end at 46 mm and are in grams. The reported value of a peel test result is a peal load value employing MTS TESTWORKS software with a peak criteria of 2%. Additionally, the peel force value is normalized to be stated in terms of force per unit length of the "width" dimension of the fastener component on the test specimen, such as grams per inch or grams per centimeter. The MTS TESTWORKS software is available from MTS Systems Corporation, a business having offices in Eden Prairie, MN.

Shear: The shear test is used to test the force necessary to pull a hook and loop fastener apart. A rolldown machine (Cheminstruments Inc.) having a 2 kg weight, is used to engage the hook and loop material. The samples were then inserted into an Instron TM tester with a crosshead speed of 250 mm/min and pulled apart in a manner similar to that used in the peel test. The sample width used was 2.54 cm (1 inch) and the hook used was VELCRO® HTH-851 though other hooks like 3M's CS-600 may be used, as long as all samples are tested with the same hook.

Tensile: The tensile test measures the peak and breaking loads and peak and break percent elongations of a fabric. This test measures the load (strength) in grams and elongation

in percent. In the tensile test, two clamps, each having two jaws with each jaw having a facing in contact with the sample, hold the material in the same plane, usually vertically, separated by 7.6 cm (3 inches) and move apart at a specified rate of extension. Values for strip tensile strength and strip elongation are obtained using a sample size of 3 inches by 15.2 cm (6 inches), with a jaw facing size of 2.54 cm (1 inch) high by 3 inches wide, and a constant rate of extension of 300 mm/min. The Sintech 2 tester, available from the Sintech Corporation, 1001 Sheldon Dr., Cary, NC 27513, the Instron Model TM, available from the Instron Corporation, 2500 Washington St., Canton, MA 02021, or a Thwing-Albert Model INTELLECT II available from the Thwing-Albert Instrument Co., 10960 Dutton Rd., Phila., PA 19154 may be used for this test. Results are reported as an average of three specimens and may be performed with the specimen in the cross direction (CD) or the machine direction (MD).

Bulk (thickness) The caliper of a material is a measure of thickness and is measured at 146.3 grams per square centimeter (0.05 psi) with a Starret-type bulk tester, in units of millimeters.

DETAILED DESCRIPTION

This invention relates to personal care absorbent articles such as disposable sanitary napkins, diapers, incontinence garments, and the like. The materials of this invention may also find application as wipers and in the area of filtration. Nonwoven fabrics prepared with single polymer, helically crimped fibers provide improved properties in a number of areas useful for these articles.

Absorbent articles typically have at least a liquid permeable body side liner, a liquid impervious baffle, and an absorbent core between the liner and baffle. Filters and wipes may be single layer fabrics or may have multiple layers with different specialized properties.

Nonwoven materials such as carded webs and spunbond webs have been used as the body side liner in absorbent products. Open, porous liner structures have been employed to allow liquid to pass through them rapidly and help keep the wearer's skin separated from the wet absorbent pad beneath the liner. Some structures have incorporated zoned surfactant treatments in selected areas of the liners to increase the wettability of the selected regions and thereby control the amount of liquid wet-back onto a wearer's skin.

The outer cover or baffle is designed to be impermeable to liquid in order to keep the clothing or bedding of the wearer from becoming soiled. The impermeable baffle is often made from a thin film and is generally made from plastic, though other materials may be used. Nonwoven webs, films or film coated nonwoven webs may be used as the baffle as well. The baffle may optionally be composed of a vapor or gas permeable, microporous "breathable" material, that is permeable to vapors or gas yet substantially impermeable to liquid.

Absorbent articles have employed various types of absorbent cores composed of superabsorbents and/or cellulosic fibers. Particular absorbent garments may be configured with absorbent gelling particles and may include a multi-layer absorbent core arrangement having varying compositions.

In addition, other layers of material, such as those constructed with thick, lofty fabric structures, have been interposed between the liner and absorbent pad for the purpose of reducing wet-back, distributing liquid and providing a reservoir or "surge" holding ability.

Helically crimped fibers may be produced by a number of means. Figure 1 shows an apparatus of the general type used for manufacturing filaments or fibers according to the co-assigned patent applications. Apparatus 10 has a first extruder assembly 12 for producing spunbond fibers in accordance with known methods (also see US patent 5,382,400 to Pike et al.). A spinneret 14 is supplied with molten polymer resin from a resin source (not shown).

The spinneret 14 produces fine denier fibers from the exit 16, which are quenched by an air stream supplied by a quench blower 18. The air stream may differentially cool one side of the fiber stream more than the other side, thus causing bending and crimping of the fibers. Crimping creates a softer fabric by, for example, reducing the straightness of the fibers between bond points created in the thermal bonding step. Various parameters of the quench blower 18 can be controlled to control the quality and quantity of crimping. Fiber composition and resin selection also determine the crimping characteristics imparted.

The filaments are drawn into a fiber drawing unit or aspirator 20 having a Venturi tube/channel 22, through which the fibers pass. The tube is supplied with temperature controlled air, which attenuates the filaments as they are pulled through the fiber drawing unit 20 in their plastic state. The attenuated fibers are then deposited onto a foraminous moving collection belt 24 and retained on the belt 24 by a vacuum force exerted by a vacuum box 26. The belt 24 travels around guide rollers 27. As the fibers move along on the belt 24, a compaction roll 28 above the belt, which operates with one of the guide rollers 27 beneath the belt, compresses the spunbond mat so that the fibers have sufficient integrity to go through the manufacturing process. A hot air knife may be used as an alternative to the compaction roll.

A layer of meltblown fibers, comprised of from 1 to about 10 microns in diameter, preferably less than 5 micron diameter, may be introduced on top of the spunbond layer from a windup roll 30 of previously manufactured meltblown fibers. Alternatively, it is also possible to form meltblown fibers and deposit them as formed directly on the spunbond layer. The meltblown fibers are formed of resin which is preferably a thermoplastic polymer such as, but not limited to, polyolefins, polyesters, polyamides, polyurethanes, copolymers and mixtures thereof.

A second layer of spunbond fibers may be made by a spunbond apparatus 32 in a manner similar to that described for spunbond apparatus 12; i.e., a spinneret 34 produces filaments which are quenched and crimped by a quench blower 36 and attenuated by an aspirator 38. The fibers deposited on the meltblown layer are then compressed by a second compaction device 40 to form a three layer laminate comprised of spunbond-meltblown-spunbond fibers 42 (the SMS laminate).

Spunbond nonwoven fabrics are generally bonded in some manner as they are produced in order to give them sufficient structural integrity to withstand the rigors of further processing into a finished product. Bonding can be accomplished in a number of ways such as hydroentanglement, needling, ultrasonic bonding, adhesive bonding, stitchbonding, through-air bonding and thermal bonding. A preferred method is by thermal bonding. The SMS laminate 42 is moved off the belt 24 and passed between a nipped pair of thermal bond rolls 44 and 46. Bond roll 44 is a conventional smooth anvil roll. Bond roll 46 is a conventional pattern roll having a plurality of pins 48. The pins create bond points within the fabric matrix. The number and size of bond points are related to fabric stiffness; i.e., higher bond areas or more bond points per unit area produce a stiffer fabric. The SMS laminate is passed between the rolls 44 and 46 and the pins 48 imprint a pattern on the SMS laminate 42 by pressing on the anvil roll 44 where the nip pressure is controlled for uniformity.

The rolls 44 and 46 can be heated to more efficiently form fiber bonds. The rolls 44 and 46 may be heated to different temperatures. The optimal temperature range and roll differential depends on the denier, fiber composition, web mass and web density and whether monocomponent or conjugate fibers are used. For monocomponent polypropylene fibers having approximately a 3 dpf, produced at about 500 feet per minute, the temperature range is about 270 °F (132 °C), to about 340 °F (171 °C), with a preferred differential between pattern and anvil roll of about 10 °F (5.5 °C) to about 30 °F (17 °C). For monocomponent

polypropylene fibers having approximately a 1 dpf at the same production speed, the temperature range is about 240 °F (115 °C) to about 290 °F (143 °C), with a preferred differential of about 40-50 °F (22-28 °C). The overall temperature range is lower for smaller denier fibers because heat transfer is more efficient. For a given raw material, the temperature range stays generally the same, but shifts warmer or cooler, depending on conveyor speed which significantly impacts web mass and density. Preferably, the pattern roll is heated to a higher temperature than the anvil. The lower temperature on the anvil roll 44 reduces the possibility of fiber glazing and secondary fiber-to-fiber bonding between the bond points. The result of this differential bond roll temperature is that secondary fiber-to-fiber bonds are reduced without affecting the integrity of the primary bonds, therefore improving fabric drape.

After the laminate 42 passes through the bond rolls 44 and 46, it is optionally passed to a neck stretching assembly 50, comprising a pair of nipped rolls 52 and 54. The rolls 52 and 54 run under tension at a controlled speed faster than the speed of the bond rolls 44 and 46, thus stretching the SMS laminate 42 in the same direction as the path of the fabric, known as the machine direction. Neck stretching breaks fiber-to-fiber bonds and strains fibers between bond points, thereby reducing fabric stiffness. The rolls may be heated or cooled as needed to achieve desired mat properties and dimensional stability.

The neck stretched SMS laminate 42 is then optionally passed to an unnecking assembly 56 and a collection roll 66 as known to those skilled in the art such as has been generally set forth in U.S. Patent 5,810,954 to Jacobs et al.

The method according to US patent provisional application 60/257,973 (docket no. 15272) uses a single, shaped capillary for inducing differential shear between the polymer flowing in a substantially hemispherical, or half round, half of the capillary and the polymer flowing in the non-hemispherical, or shaped, half of that capillary. The method may further

include differential or directed quenching of the filaments, with the directed quenching air aimed at the shaped portion of the fiber.

The single, shaped capillary has a cutaway portion which is not more than 25 percent of the entire cross-sectional area of the substantially round circumference of the capillary. It is believed that removal of less than 25 percent of the cross sectional area of the capillary aids in the retention of substantially circular cross-section, while inducing the necessary shear differential between the round and non-round halves of the capillaries, and so provides for a robust fiber.

It is believed that other shapes like an "X" or "Y" shape or a multi-lobal shape, made from a single polymer and subjected to a differential quench treatment, as taught in US patent application 60/257,983, for example, will also produce satisfactory fibers.

US patent application 09/747,278 (docket 15274) teaches the production of single polymer crimped fibers by joining polymer streams exiting through a dual capillary spinneret design. The capillaries share a parallel border where they are adjacent each other and are specifically shaped to maximize induced shear. Differentially induced shear in the different polymer streams results in differential tensions in the joined halves of the filament. The filaments may further be subjected to differential or directed quenching which provides for setting the crimps in the filaments to further induce the crimp. The filaments may also be desirably drawn out in the spinning processing to achieve a substantially round shape which results in a robust and predictable filament.

As shown in Figure 2, the die tip 70 defines a polymer supply passage 72 that terminates in further passages defined by counterbores 74 which are connected to capillaries 76. While schematic in nature, it will be appreciated that Figure 2 shows dual capillaries 76 which are individual passages formed in the die tip 70. The differential capillary shapes are more clearly seen in Figure 3. Generally, it is preferred that the capillaries of the present

invention have a length to width ratio of between about 4:1 to about 12:1; and more preferably between about 6:1 to about 10:1, with length being defined in the direction of polymer flow and width being the capillary diameter.

Accordingly, each fiber is produced by the two capillaries of a dual capillary design. Figure 3 details an exemplary embodiment of these dual capillary designs. It is believed that the use of differently shaped capillaries to produce a single fiber causes the side of the fiber with increased shear to have a lower viscosity and lower melt strength, with subsequently higher orientation within that segment of the fiber. Differential polymer structure between the two capillaries is further believed to result in differential cooling rates between fiber segments, further helping to produce crimp.

As seen in Figure 3, the dual capillary design 112 has a first capillary 114 and a second capillary 116. The first capillary 114 has an outside border 118 and an inside border 120 located adjacent the second capillary 116 at a distance sufficiently close to cause polymer extrudate from the first and second capillaries to meld or conjoin into a single fiber. The outside border 118 is arcuate and extends over about 120 degrees. The inside border 120 is also arcuate and extends over about 120 degrees but has a smaller radius than the outside border. The second capillary 116 is shown as substantially circular such that its inside border 122, facing and adjacent the first capillary 114, is arcuate. The second capillary distal border 124, that is distal from the first capillary, is of course also arcuate. The second capillary, though shown as circular, may be substantially elliptical if desired.

US patent application 09/746,858 (docket no. 16170) teaches the production of single polymer crimped fibers by joining polymer streams from two capillaries, each having different length to diameter ratios (L/D) with the joined streams exiting through a single outlet, or hole, in the meltspun die head. Due to the different capillary structures, differently induced shear in the different polymer streams results in differential polymer orientation, crystallinity

percentage and resultant differential tensions in the joined halves of the filament. The filaments may further be subjected to quenching which provides for setting the crimps in the filaments to further induce the crimp. The filaments in one embodiment retain a substantially round shape by exiting through a round hole thus resulting in a more robust and predictable filament although the fiber shape need not be so limited.

Figure 4, details a portion of an exemplary die head 80 as set up for polypropylene homofilament spunbond crimped filament production. A counter bore 82 is located in the die head between the polymer supply channel 84 and the extrusion, or knife, edge 86, thus having its longitudinal axis in, or defining, the direction of polymer flow, as indicated by arrow 88. The counter bore 82 does not reach, or open to, the knife edge 86. In the direction of polymer flow, the counter bore 82 has a first channel 90 of about 4.00 mm diameter adjacent and connected to the polymer supply channel 84. The first channel 90 leads to a first conical feed chamber 92 whose wall slopes inwardly and downwardly by about 2.16 mm at a 60 degree angle to lead to a second, narrower, channel 94 of about 1.50 mm diameter and 7.43 mm length. The second channel 94 ends in a second conical feed chamber 96 whose walls also slope inwardly at about 60 degrees to end in a flat bottom about 0.54 mm in from the knife edge 86.

The first capillary 98 of about 0.60 mm diameter is connected to the first feed chamber 92 at about the midpoint thereof and extends parallel to the counter bore long axis to open to the air at the knife edge 86, for a total length of about 6.36 mm.

The second capillary 100 of about 0.20 mm diameter and 0.30 mm length is connected to the second feed chamber 96 conical wall and extends downwardly at about a 45 degree angle to connect with the first capillary 98 at about 0.41 mm above the knife edge, or first capillary exit hole 102.

In this embodiment the first capillary has an L/D ratio of about 10 to 1 and the second capillary has an L/D ratio of about 1.5 to 1. The L/D ratio of the capillaries may be varied to achieve the desired durability, processability and percentage of crystallinity within the fiber. Crystallinity percentage represents the amount, or percent, of crystals formed in the polymer chain. The capillaries or the exit hole may be shaped rather than round to induce further crimping.

It is believed that the higher shear produced in the polymer by travel through the shorter, narrower, second capillary will lower the viscosity of the polymer melt and induce higher polymer chain orientation than polymer travel through the larger, wider first capillary. The polymer in the first capillary will have a higher viscosity and lower polymer chain orientation, resulting in a more amorphous polymer stream. As the commingled polymer stream exits the spinneret into the air, it is preferably quenched on both sides to fix the orientation of the extrudate. The highly oriented side will shrink to a greater degree, causing crimping of the fiber.

US provisional patent application 60/257,982 (docket no. 15620) teaches the treatment of helically crimped homofilaments with sufficient hot air flow to accelerate the fibers' natural tendency to crimp. This also sets the crimps without substantial melt bonding or relaxation of the crimped fibers in order to retain the lofty structure of this layer of the laminate. Various other layers may then be bonded, such as by thermal point bonding, to create a laminate which retains the essential characteristics of each layer. The layers may, for example, be bonded together with sufficient integrity to create a laminate that will withstand high speed web transfer processing without harm to the processing equipment or the material. This process preferably uses a hot air knife, a device now known to those skilled in the art and described in US patent 5,707,468 to Arnold et al, to which has been

attached a diffuser mechanism which can end in a plate with multiple perforations for escape of the hot air, rather than as a concentrated line in the HAK.

The dwell time, air temperature, and flow rates of the hot air knife are adjusted according to polymer type and fiber morphology of the crimped fibers. An exemplary homofilament polypropylene helical spunbond layer has been treated with desired results by diffuse airflow. The flow rate was about 275 meters per minute or mpm (900 feet per minute or fpm) over a 45.72 cm (eighteen inch) length in the machine direction at between 61 and 366 mpm (200 and 1200 fpm) material traversal rates. Further satisfactory results were obtained with a diffuser plenum extending 20.32 cm (eight inches) in the machine direction, at air temperatures of between 132 – 143 degrees C (270 - 290 degrees F), at an airflow rate of between 213 and 259 mpm (700 and 850 fpm), supplied at a distance of 2.54 cm (one inch) from the forming wire, and material traversal rates of between 91 and 244 mpm (300 fpm and 800 fpm).

US provisional patent application 60/257,972 (docket no. 15814) teaches a first layer of nonwoven filaments deposited onto a forming belt, or foraminous wire, an optional intermediate layer, and a layer of lofty nonwoven filaments such as e.g., helically crimped homofilaments deposited over the first layer and any in-place intermediate layers. The first layer is treated, such as by known hot air knife treatment, to bond the first layer into a web with sufficient integrity to withstand high speed web transfer handling. The optional intermediate layer may or may not be heat treated depending on fiber type, desired laminate functionality, or morphology, or the like. The layer of lofty nonwoven filaments is treated in-line on the forming belt with sufficient heat to set the crimps without substantial melt bonding or crimp relaxation of the crimped fibers in order to retain the lofty structure of this layer of the laminate. The various web layers, i.e., the first layer for mechanical integrity, the second lofty, helical crimped, layer, and any intermediate layers are then bonded, such as by thermal

point bonding, to retain the essential characteristics of each layer and bond the layers together with sufficient integrity to create a laminate that will withstand high speed web transfer processing without harm to the processing equipment or the material. It will be understood that manufacturing speeds will be dependent on the materials being formed, but the present invention should have few practical limits in this regard and may accommodate web speeds by way of example only, in the range of 200 to 2000 feet per minute. It has been found that the crimps of a single component crimped thermoplastic fiber web may be crystallized, or set, to retain their loft through low applications of heat as in US patent 6,123,886 to Slack. Slack teaches a method of making a substantial helical crimp in a continuous filament by generating turbulence in thermoplastic material intended to form the filament while it is at its glass transition phase temperature and maintaining the turbulence while the polymer crystallizes. This treatment, however, does little to increase the integrity of the web for modern, high-speed, line-transfer manufacturing, and, as taught in Slack, is a slow, off-line process unsuitable for economical manufacture rates.

The crimped fiber laminate material made in this manner can be useful for high loft and high bulk applications such as the loop portions of hook and loop fasteners. The fibers may be designed to produce fabric of good softness and drape while keeping sufficient bulk and loft to aid in the cloth like feel.

The materials of this invention may be made from synthetic polymers. Synthetic fibers include those made from polyolefins, polyamides, polyesters, rayon, acrylics, superabsorbents, LYOCELL® regenerated cellulose and any other suitable synthetic fibers known to those skilled in the art. Many polyolefins are available for fiber production, for example polyethylenes such as Dow Chemical's ASPUN® 6811A liner low density polyethylene, 2553 LLDPE and 25355 and 12350 high density polyethylene are such suitable polymers. The polyethylenes have melt flow rates, respectively, of about 26, 40, 25 and 12.

Fiber forming polypropylenes include Exxon Chemical Company's ESCORENE® PD 3445 polypropylene and Himont Chemical Co.'s PF304. Other polyolefins are also available.

A number of examples were prepared using different fibers, in order to test the fabrics of the invention. The fibers used were helically crimped single polymer fibers made according to US patent 6,123,886, helically crimped bicomponent fibers and mechanically crimped polypropylene fibers.

The helically crimped single polymer fibers (Fiber 1) had a denier of 7 and were made from polypropylene. These fibers were produced as continuous fibers and subsequently cut into staple lengths of approximately 50 mm.

The bicomponent crimped fibers (Fiber 2) had a denier of about 6 and were made from polypropylene and polyethylene. These fibers were cut into staple lengths of 50 mm.

The mechanically crimped fibers (Fiber 3) also had a denier of about 6 and were cut into staple lengths of about 50 mm.

Each of the fibers was processed into a nonwoven web according to known bonded carded web processes at two different basis weights. All webs were bonded with a point unbonded pattern. The six nonwoven webs were tested for bulk, shear and peel strength, compression, resilience and density. The results are given in Table 1. In Table 1, basis weight is given in grams per square meter, bulk in mm, shear and peel were measured in the cross machine direction and are in grams, compression is given in mm for a test using a 2.54 cm (1 inch) diameter foot at a pressure of 292.7 gram-centimeter squared (0.1 psi), the resilience is the difference between the load and unload heights and the density is given in grams per cubic centimeter.

Table 1

	Fiber 1	Fiber 1	Fiber 2	Fiber 2	Fiber 3	Fiber 3
Basis weight	48.5	31.9	52.3	23.3	51.2	26.8
Bulk	13.7	8.6	9.4	5.1	7.6	4.6
Shear	2724	2510	2493	2390	2914	2593
Peel	76	28	48	45	51	49
Compression (load)	1.12	0.58	0.71	0.33	0.66	0.41
Compression (unload)	0.71	0.38	0.48	0.15	0.51	0.25
Resilience	0.64	0.65	0.68	0.46	0.77	0.63
Density	0.0035	0.0037	0.0056	0.0046	0.0067	0.0059

As can be seen from Table 1, the shear and peel characteristics of the single polymer helically crimped fiber web are superior to that of the bicomponent crimped fibers, except for the shear of fiber 1 at 31.9 gsm. The bulk was much greater for the single polymer helically crimped fiber web, indicating an advantage in fluid handling applications in personal care products, as well as in hook and loop fastening applications as a loop material. The high bulk and good resilience of the single polymer helically crimped fiber web also indicates a high void volume (and low density), also a positive indicator for a successful fluid handling layer.

Another example was performed using helically crimped fibers but made according to the spunbonding process. The fibers used were single component helically crimped spunbond fibers and helically crimped bicomponent fibers.

The helically crimped single polymer fibers (Fiber 4) had a denier of 7 and were made from polypropylene. These fibers were made according to US patent provisional application 60/257,973 and had about 25 percent of the cross sectional area of the capillary removed to induce shear.

The bicomponent crimped fibers (Fiber 5) had a denier of about 6 and were made from polyethylene and polypropylene in a side-by-side configuration. These fibers were made according to US patent 5,382,400 to Pike et al.

Each of the fibers was processed into a nonwoven web according to known spunbonding processes at two different basis weights. All webs were thermally bonded using a point un-bonded pattern. The four nonwoven webs were tested for shear and peel strength, percent opacity, machine directional tensile strength, cross-machine tensile strength, compression and resilience using the procedures herein. The results are given in Table 2. In Table 2, basis weight is given in grams per square meter, shear and peel were measured in the cross machine direction and are in grams, compression is given in mm for a test using a 2.54 cm (1 inch) diameter foot at a pressure of 292.7 gram-centimeter squared (0.1 psi) and the resilience is the difference between the load and unload heights.

Table 2

	Fiber 4	Fiber 4	Fiber 5	Fiber 5
Basis weight	**48.8**	**23.4**	**52.5**	**25.4**
Shear	**1210**	**585**	**872**	**993**
Peel	**115**	**58**	**161**	**176**
Opacity	**55.4**	**38.8**	**44.8**	**25.3**
Compression (load)	**0.61**	**0.36**	**0.58**	**0.41**
Compression (unload)	**0.46**	**0.23**	**0.41**	**0.23**
Resilience	**0.75**	**0.64**	**0.70**	**0.56**
Tensile MD	**12.4**	**8.2**	**7.7**	**2.5**
Tensile CD	**8.1**	**5.0**	**3.7**	**1.1**

The resilience of the single component helically crimped fibers was greater than that of the bicomponent fibers, especially if normalized for basis weight, as were the tensile

strengths. The opacity of the single component helically crimped fibers was also greater, indicating the possible application for this fabric where stain hiding properties are desired, such as in an outercover or liner for personal care products.

Tenacity testing of the fibers 4 and 5 made at about 4.7 denier, revealed a tenacity in gm/denier of 1.9 and 1.4 respectively, showing the fibers according to the invention to be stronger than comparable crimped bicomponent fibers.

The testing of the single polymer helically crimped fiber webs indicates that they will be good surge materials in personal care products. Surge control materials are provided to quickly accept an incoming insult and either absorb, hold, channel or otherwise manage the liquid so that it does not leak outside the article. The surge layer may also be referred to as an intake layer, transfer layer, transport layer and the like. A surge material must typically be capable of handling an incoming insult of between about 60 and 100 cc at a volumetric flow rate of from about 5 to 20 cc/sec, for infants, for example.

Superabsorbent polymers may also be used to produce single polymer helically crimped fibers for use in the nonwoven webs of this invention. Superabsorbents are normally used in particulate form in absorbent cores since they absorb many times their weight in liquid. A particular problem for prior absorbent cores using particulate superabsorbents has been "gel blocking", a condition whereby the superabsorbent particles swell and impede or prohibit entry of additional liquid to be absorbed. Particulate superabsorbent may also leak from the product much more easily than fibrous superabsorbent. The large void volume and good resilience associated with helically crimped fibers should alleviate the problem of gel blocking to a large degree, maintaining open pores in the absorbent structure for continued liquid intake for a longer period of time than conventional absorbent cores.

Superabsorbents that are useful in the present inventions can be chosen from classes based on chemical structure as well as physical form. These include superabsorbents with

low gel strength, high gel strength, surface cross-linked superabsorbents, uniformly cross-linked superabsorbents, or superabsorbents with varied cross-link density throughout the structure. Superabsorbents may be based on chemistries that include but are not limited to acrylic acid, iso-butylene/maleic anhydride, polyethylene oxide, carboxy-methyl cellulose, poly vinyl pyrrollidone, and poly vinyl alcohol. The superabsorbents may range in rate from slow to fast. The superabsorbents must be capable of being made into a fiber. The superabsorbents may be in various degrees of neutralization. Neutralization occurs through use of counter ions such as Li, Na, K, Ca. Examples of superabsorbents obtained from Camelot are designated FIBERDRI® 1241 and FIBERDRI® 1161. Examples of these types of superabsorbents obtained from Technical Absorbents, Ltd. are designated as OASIS® 101 and OASIS® 111. Another Example included in these types of superabsorbents is obtained from Chemtall Inc. and is designated FLOSORB® 60 Lady. Another Example included in these types of superabsorbents is obtained from Sumitomo Seika and is recognized as SA60N Type 2. Additional types of superabsorbents not listed here which are commonly available and known to those skilled in the art can also be useful in the present inventions.

The nonwoven fabrics of this invention may be made with various physical parameters dependent upon its end use. The fabric may be made with a basis weight, for example, from about 20 to 80 gsm for lighter weight applications and from 80 to 150 gsm for heavier weight applications. Lighter weight applications include, for example, liners, loop materials and outercovers and heavier weight applications include surge and absorbent core materials, filtration media, and wipers. The density of the web may be varied from about 0.002 to 0.05 g/cm^3. The degree of crimp may be controlled using the variables of quench temperature, L/D ratio, shape of capillary, type of polymer, and polymer flow rate. The denier of the fiber used to make the nonwoven web of this invention may also be adjusted in order to change the behavior of the web. The denier will affect, for example, the wicking properties of the

web. The properties of the web may be affected also by chemical treatments. These treatments include anti-statics and surfactant designed to change the hydrophilicity of the fibers.

As will be appreciated by those skilled in the art, changes and variations to the invention are considered to be within the ability of those skilled in the art. Examples of such changes are contained in the patents identified above, each of which is incorporated herein by reference in its entirety to the extent it is consistent with this specification. Such changes and variations are intended by the inventors to be within the scope of the invention.